Carbon dioxide exchange between the atmosphere and a secondary tropical peat swamp forest in Sarawak, Malaysia

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Introduction

Tropical peatland is one of the world massive reservoirs of terrestrial carbon. Therefore, the exchange of carbon dioxide (CO_2) of tropical peat ecosystems play an important role in the global carbon cycle and climate change. In peatland, soil respiration would have important contribution to ecosystem respiration (RE) owing to its large soil carbon stock. Groundwater level (GWL) controls soil aerated zone where peat decomposition takes place. Low GWL increases the aerated zone, thus theoretically increases oxidative decomposition of peat organic carbon, and consequently increases RE. However, in secondary forest dominated by rapidly-growing young vegetation, CO_2 uptake (GPP) may overcome RE. In order to assess CO_2 balance (NEE), CO_2 flux was measured above a secondary peat swamp forest in Sarawak, Malaysia. The objectives are 1) to investigate the environmental controls on CO_2 fluxes (GPP and RE), 2) to investigate seasonality in CO_2 fluxes and 3) to assess annual NEE and discuss its interannual variation.

Materials and Methods

The study site was located in a secondary peat swamp forest in Sarawak, Malaysia. A tower was built in a “padang paya” forest close to the center of the peat dome (01°24’N, 111°23’E). Peat depth around the tower is about 10 m. Canopy height was about 25 m. Leaf area index was 7.9 $m^2 m^{-2}$ in Apr.-Mar. 2013. CO_2 and energy fluxes have been measured by the eddy covariance technique at the height of 41 m since Jan. 2011 using a sonic anemometer/thermometer (CSAT3, CSI) and an open-path CO_2/H_2O analyser (LI7500A, LICOR). CO_2 storage change in the space under the flux measuring height was calculated form CO_2 profile measured using a closed-path CO_2 analyser (LI-820, LICOR). NEE was calculated as the sum of eddy CO_2 flux and CO_2 storage change every 30 min. After quality control, NEE was partitioned into RE and GPP using a conventional method. Gaps of NEE data were filled using the marginal distribution sampling method. Photosynthetic photon flux density (PPFD), air temperature and relative humidity were measured at 41m. GWL, precipitation and volumetric soil water content were also measured.

Results and Discussion

Precipitation and GWL showed clear seasonal variations. Generally, based on monthly mean GWL, the wet season begins in Oct. and lasts until Mar. After three months of the transition period, the dry season occurs in Jul. until Sep. In 2011, no clear seasonal variation was observed in NEE, whereas the lowest GWL were recorded in Aug. among the three years between 2011 and 2013. In 2012 and 2013, however, NEE peaked in Aug. with monthly means of 2.0 and 1.7 gC m^{-2} d^{-1}, respectively. Similar patterns were observed in monthly RE. Monthly GPP shows no clear seasonality in all three years. Large annual precipitation in 2011 (2965 mm yr^{-1}) following a La Nina event may cause RE to be almost stable throughout the year. Although the lowest GWL was recorded in 2011, the dry season was the shortest among three years. The short dry season would restrict oxidative peat decomposition, which resulted in smaller RE. Almost stable GPP throughout the year indicates that vegetation in peat swamp forest were less stressed by low GWL in the dry season, probably because of the extensive root systems of swamp trees. These results indicate that the increase in NEE, or net CO_2 emissions, during the dry period was mainly attributed to the increase in RE, which was most likely governed by oxidative peat decomposition.